A Pre-synopsis entitled as

Mycological DiseaseManagement of Stem Rot of Groundnut (*Arachis hypogea* L**.)**
Caused by *Sclerotium rolfsii* Sacc**.**

submitted to

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Introduction:

Groundnut is considered as one of the most important crops in the world. Groundnutis the 4th most important source of edible oil, and is ranked as 3rd most important source of vegetable protein in the world (Smith,2002). Groundnut (*Arachis hypogea*, L.) is an annual legume and it is also known as peanut, earthnut, goober pea, goober, jack nut, manila nut, pygmynut,pignut,andmonkeynut.Itisalsoknownas'KingofOilSeeds'.Groundnutisone of the widely cultivated and produced oilseed crop in the World. It is cultivated in more than 100 countries of the world. That's why it is referred as a "UniversalCrop".

Groundnut is grown on a large scale in almost all tropical and subtropical countries of the world. It is estimated that around 65% of the crop produced in the world is crushed to extract groundnut oil and the rest is used in making other edible products. The most important groundnutgrowingcountriesareIndia,China,Nigeria,SudanandUSA(HandbookonGrading of Food Grains and Oilseeds). Groundnut is one of the most important food and cash crops of our country. While being a valuable source of all the nutrients, it is a low-priced commodity. Groundnut is also called as wonder nut and poor man's cashew nut. Groundnut (*Arachis hypogea*, L.) belongs to the familyFabaceae.

Groundnut kernels contain 47-53% oil and 25-36% protein. The cultivated groundnut orpeanut(*Arachishypogea*L.) has beenoriginatedinSouthAmerica.Theterm*Arachis*isderivedfrom theGreekword"arachos",meaningaweed,andhypogea,meaningundergroundchamber,that is in botanical terms, a weed with fruits produced below the soil surface. Groundnutisgrownoveranarea of 24.7million hectares with a total production of 33 million tonnes in whole World. India occupies the first place in acreage and second in production after China. China is the largest producer as well as consumer of groundnut in the world with 166.24 lakh tonnes followed by India (68.57 lakh tonnes), Nigeria (30.28 lakh tonnes) and United States (25.78 lakh tonnes. (https://pjtsau.edu.in/files/AgriMkt/2018/GroundnutOLNov2018.pdf).

In India, Gujarat is the largest producer contributing 33 per cent of the total production of Groundnut, followed by Rajasthan (21 %), Tamil Nadu (14 %). Andhra Pradesh contributes 7% and Telangana contributes 5 % to total Groundnut production. Groundnut production contributes around 87 per cent of acreage and 91 per cent of production to total oilseeds in AndhraPradesh.Groundnutcontributes19.1percentareaand21.3percentproductiontototal oilseeds area and production in India respectively. (https://angrau.ac.in/downloads/AMIC/GROUNDNUT%20OUTLOOK%20REPORT%20-%20January%20to%20May%202021.pdf).

Groundnutisavaluablesourceofprotein,Niacin,Fibre,vitaminEandantioxidants.The groundnut seed is a good source of edible oil and proteins in the form of oil cake, which can also be used as animal fodder and fertilizer. It also has some industrial uses like in paint, varnish, lubricating oil, soap, furniture, polishetc.

Groundnut crop is prone to attack by many diseases and to a much larger extent than many other crops. More than 100 pathogens, including viruses, have been reported to affect groundnutbutonlyafewareeconomicallyimportantinIndiasuchasleaf-spots(Tikka),Early leaf-spot (*Cercospora arachidicola*), Late leaf-spot (*C. personatum*),rust (*P. arachidis*), and aflatoxin contamination (*Aspergillus flavus* and *A. parasiticus*). The other diseases suchas Collarrot(*A.niger*),Stem-rot(*S.rolfsii*),Root-rot(*M.phaseolina*),Budnecrosis(tomatospotted wilt virus), Clump and Peanut (groundnut) mottle disease are localized (Subrahmanyam *et.al.*,

1980).

The control of fungal diseases of plants by the use of naturally occurring antagonistic micro-organisms has been the focus of intense research throughout the world. This approach is popularly known as biological control of plant pathogens. Biological control is a bio-based, ecofriendly strategy that offers a practical and economical alternative for the management of plant pathogens with a potential to emerge as an alternative to chemical control (Mark *et al.*,2006).

2. Review of literature and Development in subject:

*Sclerotiumrolfsii*Sacc,thecausalagentofgroundnutstemrot,isanimportantsoilborne pathogen in many areas of the world where groundnut (*Arachis hypogea* L.) is grown. The fungus infects lower stems of groundnut, which are in contact with the soil as well as pegs, pods and roots. Infected plants show wilting of one or few branches initially, but the whole plant may wilt and die within few weeks of infection. Whitish fungal mycelium and light-to-dark-brown sclerotia appear on the soil surface and diseased plant tissues (Lindermann and Gilbert 1973, Punja and Rahe1992).

The traditional agricultural practice to control the phytopathogen *S. rolfsii* is by using variety of fungicides e.g.Bavistin, Captan etc. But a severe disadvantage of the traditional method is that it is not effective to check the *Sclerotium* during the cropping period (90- 100 days)andisnoteco-friendly.Becauseoftheincreasedusageofchemicalfungicides,produced concern for the environment and human health, microbial inoculants have been experimented extensively during the last decade to control wilt and other plant diseases (Siddiqui and Shakeel, 2006; Chakraborty and Chatterjee, 2008; Akhtar *et al.*, 2010). Biological control of plant diseases has been studied extensively as an alternative to chemicalcontrol.

The present study is planned for the management of stem rot disease of groundnut by usingdifferentecofriendlyfungi.Sufficientliteratureisavailableonmycologicalmanagement of stem rot disease which are representedas:

Abd-El-Moity *et al.,* (2003) found that different antagonistic isolates varied in their effect against cucumber soil and air borne pathogens. In general, Fungal spp. isolates werethe mosteffectiveantagonistsagainstalltestedsoilbornepathogens(*Sclerotiumrolfsii*,*Fusarium solani* and *Rhizoctonia solani*). On the other hand, *Bacillus subtilis* and *Streptomyces spp*. showed slight effect against the tested pathogens. The most effective method in controlling cucumberdampingoffwheresoildrenchorseeddressingusing*T.hamatum*and*T.harzianum*. The highest yield was obtained with the consortium of *P fluorescens, B. subtilis* and *Fungal spp*. All antagonists showed the highest effect when the treatments were repeated weekly. Cucumberplantsreceivedbioagenttreatmentsatearlystages(4weeksold)werehealthiercompared to those receiving the same initial treatments after 5 – 6weeks.

Manjula *et al.,* (2004) evaluated 57 bacterial isolates and 13 isolates of Fungal spp. for their antagonistic activity against *Sclerotium rolfsii*. The antagonists were selected based on their ability to inhibit the external growth of *S. rolfsii* from infected groundnut seeds. Four

isolates of *Pseudomonas fluorescens*, GB 4, GB 8, GB 10 and GB 27, and *T. viride* pq1 were identified as potent antagonists of *S. rolfsii*. *T. viride* pq1 produced extracellular chitinase and parasitizedthemyceliumof*S.rolfsii*.Undercontrolledenvironmentconditions,*P.fluorescens* GB 10, GB 27, *T. viride* pq1 and the systemic fungicide Thiram® reduced the mortality of *S. rolfsii* inoculated to groundnut seedlings by 58.0%, 55.9%, 70.0% and 25.9%, respectively compared to control. *In vitro* growth of *P. fluorescens* GB 10 and GB 27 was compatiblewith *T. viride* pq1 and Thiram®. Integrated use of these two bacterial isolates with *T. viride* pq1 or Thiram® improved their biocontrol efficacy. Combined application of either GB 10 or GB 27 with *T. viride* pq1 was significantly effective than that with Thiram® in protecting groundnut seedlings from stem rot infection.

Radawan *et al.*, (2006) reported that *Trichoderma harzianum* and *Trichoderma hamatum* were most effective against *Sclerotium rolfsii* and inhibited the mycelial growth by 79%.

Deng, *et al.*, (2007) isolated endophytic *Trichoderma longibrachiatum* EF5 from rice and demonstrated that *T. longibrachiatum* EF5 inhibits the growth of *S. rolfsii* pathogens by direct interaction as well as via the production of the microbial volatile organic compounds (mVOCs). The mVOCs also reduced mycelial growth and inhibited the production of sclerotia by altering the mycelial structure.

Bagwan (2011) isolated and screened 46 isolates of Fungal spp. belonging to *Trichoderma spp*viz., *virideae*, *harzianum*, *hamanatum*, *ressei* and *koningii* species for their modes of biocontrol ability against *Sclerotium rolfsii* Sacc., *Aspergillus niger* van Teighem and *A. flavus* Link ex Fries, the causal agents of stem rot, collar rot and aflaroot of groundnut, respectively. The isolates T005, T043, T095, T49, T126, T144, T166, T191, 250, 390 and T425 gave maximum inhibition of mycelial growth of *S. rolfsii* in dual culture and killed the sclerotia.

Doley, and Jite, (2012) carried out an investigation in laboratory condition towards biological efficiency of *T. virideae* on potato dextrose agar (PDA) medium for the biocontrol of soil-borne plant pathogens *Sclerotium rolfsii* and *Macrophomina phaseolina* in *in-vitro* condition. In dual culture technique, *T. virideae* significantly inhibited the mycelial radial growth of *S. rolfsii* by 75% and *M. phaseolina* by 71.42%.

Basumatary *et al.*, (2015) have selected six fungal species viz. *Penicillium sp, Curvularia sp Aspergillusniger,Trichodermaharzianum,Trichodermaviride*and*Fusariumspp*asbio-agents against *Sclerotium rolfsii*. The maximum percentage of growth inhibition of *Sclerotium rolfsii* was observed with *Trichoderma harzianum* (77.39%) and *Trichoderma viride* (76.54%), while *Penicillium sp* (29.05%), *Aspergillus niger* (30.48%), *Curvularia sp* (13.57%) and *Fusarium sp.* inhibited the growth by 3.02% under in vitro condition. *Trichoderma species* produced β- xylosidase, α-glycosidase, β-glucosidase, cellobiohydrolase, trypsin, chymotrypsin and chymoelastase-like proteases and N-acetyl β-glucosaminidase which are responsible for the biocontrol activity of Sclerotiumrolfsii.

Doley*etal.*,(2017)investigatedthattheinoculationofarbuscularmycorrhizal fungi(AMF)andFungalspeciesfoundtobeworthapplyingastheystimulatedgrowthand

decreasedharmfuleffectsof*S.rolfsii*.Thelow-inputAMfungialongwithFungalspeciesmay be needed for the advancement of modern agriculturalsystems.

Wonglom *et al.,* (2019) evaluated five Fungal spp.against *Sclerotium spp.* SZ01 and LS01whichcausedFruitrotofsnakefruitandstemrotoflettucerespectively.*Fungalsp.*T76-12/2showedsignificantinhibitoryeffectsonmycelialgrowthof*Sclerotiumsp.*LS01andSZ01 with 81.48% and 78.33% inhibition. While Fungal sp. T76-12/2 caused discoloration of *Sclerotium sp.* mycelia at the contact point. Volatile antifungal bioassay revealed Fungal sp.T76-12/2 was superior in inhibiting the growth of *Sclerotium sp.* by up to 44.44% for LS01 and by 59.52% forSZ01.

Objectives of research:

Considering the importance of Groundnut crop and the influence of *Sclerotium rolfsii* on productivity, following objectives are set to explore the problem and study it in detail to findout management strategies for control of *Sclerotium rolfsii*, and to improve the yield of Groundnut crop in a cost-effective and eco-friendly manner.

- Isolation of stem rot pathogen from infected Groundnut crop and testing of its pathogenicity.
- Isolationoffungalspp.fromrhizosphericsoilanditsscreeningforinhibitionof *Sclerotium rolfsii* by *in vitro* method.
- Identification of the efficient fungalspp.
- Illustration of biocontrol mechanism of efficient fungal spp. against*Sclerotium rolfsii.*
- Preparation of a carrier-based user-friendly formulation of efficient fungalspp.
- Confirmation biocontrol ability of selected fungal spp. by Potassay.
- Exploration of growth promoting ability of efficient fungalspp.

Hypotheses:

Conventionally farmers use fungicides as well bactericides to protect the crop from diseases. Chemical control is one of the promising strategies for management of phytopathogens of crops. However, use of fungicides and bactericides cause environmental pollution. The proposed hypothesis is mainly targeted on the control of plant diseases using naturally occurring antagonistic fungi. This approach is popularly known as biocontrol of plant pathogens.

Biocontrol is a bio-based, eco-friendly strategy, offers a practical and economical alternative for the management of plant pathogens with a potential to emerge as an alternative to chemical control. Due to these facts about the management of Phytopathogen, there is need to search for eco-friendly, target specific alternative for the management of Stem Rot Disease of Groundnut.

Research Methodology:

To confront this problem, following methodology will be adopted.

1. **Isolation of Stem Rot pathogen from infected Groundnut crop and its pathogenicity testing:**

For isolation of Phytopathogen, infected Groundnut crop will be collected from different fields and brought to laboratory in polythene bags. Isolation of Phytopathogens will be carried out by method used by (Rakh, 2010) from infected stem. Pathogenicity test will be carried out to prove the Koch's postulates. Fungal phytopathogens will be identified by using the book Subramanian (1971).

2. **Isolation of Fungal spp. from rhizospheric soil and its screening for inhibition of *Sclerotium rolfsii* by *In vitro* method.**

For isolation of rhizospheric Fungal spp., rhizospheric soils from different fields will be collected in polythene bags and brought to laboratory. Isolation of *Fungal spp.* will be carried out by using method followed by Nor and Norazwina, (2018) and its screening for efficient biocontrol will be done by method of Rakh *et al.,* (2020)

3. **Identification of Efficient Fungalspp.:**

Identification of efficient Fungal spp. will be carried out by morphological, cultural biochemical characteristics.

4. **Illustration of Mycological Management of Mechanism of Efficient Fungalspp.:**

To illustrate the biocontrol mechanism, the efficient Fungal spp. will be tested to produce antibiotics, mycoparasitism, and cell wall degrading enzymes (Naher, *et al.,* 2014).

5. **Preparation of formulation for easy use of Mycologicalagent:**

Carrier based powder formulation (CBPF) of microbial control agents will be prepared and used for further study.

6. **Pot Assay for Mycological control:**

By using the Pot Assay, the biocontrol ability of selected Fungal spp. will be carried out according to Rakh *et al.,* (2022).

7. **Growth Promotion ability:**

Growth promoting ability of Fungal spp. will be analyzed by direct inoculation in Pot and studying different parameters Rakh *et al.,* (2022).

Importance of Study:

International Status:

Internationally, several investigators have reported the inhibition of growth and *sclerotial* production in *S. rolfsii* by microorganisms as follows:

Guzmán-Valle*et al.,*(2014)reported inhibition of *S. rolfsii* by *T. asperellum* in in vitro and also induced resistance in Onion.

Bastakoti*et al.,* (2017) isolated five different *Trichoderma* species from 26 various soil samples and tested againstfour fungal soil borne pathogens. Inhibition percentage of radial growth of *Sclerotium rolfsii* by three of the *Trichoderma* isolates was found to be 100%; about 62% and 68% of maximum inhibition was observed against *Rhizoctonia solani* and *Fusarium solani* respectively whereas *Sclerotionia sclerotiorum* was inhibited maximum up to 23%.

Loc*et al.,* (2020) reported inhibition of *Sclerotium rolfsii* upto 97 % by using *T. asperellum PQ34* which produced chitinase enzyme in order to inhibit the *Sclerotium rolfsii*.

Abo-Zaid*et al.,* (2021) tested ten actinobacterial isolates, *Streptomyces cellulosae* Actino 48 exhibited the strongestsuppression of *Sclerotium rolfsii* mycelium growth and the highest chitinase enzyme production(49.2 U L^{-1} min^{-1}). The interaction between Actino 48 and *S. rolfsii* was studied by scanningelectron microscope (SEM), which revealed many abnormalities, malformations, and injuries of thehypha, with large loss of *S. rolfsii* mycelia density and mass.

National Status:

In India, the National Institute actively involved in the management of stem rot diseases of groundnut crop. Research Institute and Several investigators have reported inhibition of *S. rolfsii,* few of them are as follows.

Parmar *et al.,* (2015)tested Six Trichodermastrains for their ability to inhibit soil born pathogen of groundnut mainly*Sclerotium rolfsii*(causing stemrot on groundnut). In vitro percent growth inhibition of *S.rolfsii* by various *Trichodermastrain* was recorded at 5 days after inoculation at 28 °C in the 90 cm Petri plates. Results obtained from the antagonism study indicated that *Trichodermaviride* (NBAII Tv 23) inhibited 61% growth of phytopathogenic

fungi *S.rolfsii*followed by *T. harzianum* (NBAII Th1) (55% growth inhibition of pathogen). This suggested that among different Trichodermastrains, *T. viride*was the best bio-control agent to inhibit in vitro growth of phytopathogen *S.rolfsii*.

Singh*et al.,* (2016)studied the antagonistic potential of *Trichoderma strains* by studying the effect of theirculture filtrate on the radial growth of *Sclerotium rolfsii*, the causal agent of chickpea collar rot and found that*Trichoderma harzianum*-1432 (42.2%) and *Trichoderma atroviride* (40.3%) were found tobe strong antagonists.

Doley*et al.*,(2017)tested the inoculation of arbuscular mycorrhizalfungi (AMF) and *Trichoderma* species for growth achievement and disease control. The investigation showed thatthese microbial strains were found to be worth applying as they stimulated growth and decreased harmful effects of *S. rolfsii*(cv. 'Western-51'). The increased biochemical parameters and antioxidant activities also indicated their defence relatedactivities in groundnut plants. Despite positive attributes meted out by these microbial strains towards groundnut crop, theinteraction among AM fungi and *Trichoderma* species seemed to be less co-operative between each other which were notedwhen mycorrhizal dependency and percent root colonization were observed.

Significance of the study:

To improve the yield of groundnut both quality and quantity wise and to satisfy the demands of ever-increasing population. In this context variety of synthetic agrochemicals are usedbyfarmerstocontrolthePhytopathogensattackingthecrop.Thispracticehasledtomany environmental crises like i) Disturbance of ecological balance of soil. ii) Contamination of ground water. iii) Development of resistance among the pathogens towards the synthetic chemicals. iv) Sever health risk to non-target species likehumans.

So,thereisneedofpermanentandassuredsolutiontotheproblemofapplyingsynthetic agrochemicals in agriculture for control of the phytopathogens by farmers. To cope up with this problem an attempt will be made through this research work by using a target specific, rhizospheric fungus for efficient control of phytopathogen causing Stem rot disease to groundnut, in an eco-friendly and cost-effectivemanner.

Significance of this study is in the fact that the groundnut growers can get an alternative for management of stem rot phytopathogen. Microbial control agents along with control of diseases also promote the growth of plants without additional application of fertilizers. Hence fertilizer input can also be reduced.

Plan of work (Time schedule of activity):

Sr. No.	**Duration** (Month)	**Work to done**
1.	6 months	Isolation of Stem Rot pathogen associated with Groundnut and its Pathogenicity testing.
2.	12 months	Isolation of Fungal spp. and its screening for inhibition of *Sclerotium rolfsii* by *In vitro* method.
3.	18 months	Identification of efficient Fungal spp.
4.	24 months	Illustration of Mycological Control Mechanism of Efficient Fungal spp.
5.	30 months	Preparation of formulation for easy use of Mycological agent.
6.	36 months	Pot Assay for Mycological control and Growth Promotion ability of Mycological agent.

References:

1. Abd-El-Moity, T. H., Abed-El-Moneim, M. L., Tia, M. M. M., Aly, A. Z., & Tohamy, M. R. A. (2003). Biological control of some cucumber diseases under organic agriculture. ISHS. *Acta Horticulture*, *608*.
2. Abo-Zaid, G., Abdelkhalek, A., Matar, S., Darwish, M., & Abdel-Gayed, M. (2021). Application of bio-friendly formulations of chitinase-producing Streptomyces cellulosae Actino 48 for controlling peanut soil-borne diseases caused by Sclerotium rolfsii. *Journal of Fungi*, *7*(3), 167.
3. Akhtar MS, Siddiqui ZA (2010) Role of Plant growth promoting rhizobacteria in biocontrol of plant diseases and sustainable agriculture. In: Maheshwari DK (ed) Plant growth and health promoting bacteria, vol 18, Microbiology monographs. Springer, Berlin/Heidelberg, pp 157–196.
4. Bagwan, N. B. (2011). Evaluation of biocontrol potential of Trichoderma species against Sclerotium rolfsii, Aspergillus niger and Aspergillus flavus. *Int. J. Plant. Prot*, *4*, 107-111.
5. Barakat, R. M., Al-Mahareeq, F., & Al-Masri, M. I. (2006). Biological control of Sclerotium rolfsii by using indigenous Trichoderma spp. isolates from Palestine. *Hebron university research journal*, *2*(2), 27-47.
6. Bastakoti, S., Belbase, S., Manandhar, S., & Arjyal, C. (2017). Trichoderma species as biocontrol agent against soil borne fungal pathogens. *Nepal Journal of Biotechnology*, *5*(1), 39-45.
7. Basumatary, M., Dutta, B. K., Singha, D. M., & Das, N. (2015). Some in vitro observations on the biological control of Sclerotium rolfsii, a serious pathogen of various agricultural crop plants. *IOSA Journal of Agriculture and Veterinary Science*, *8*, 87-94.
8. Chakraborty M.R. & Chatterjee N.C. (2008) Control of fusarium wilt of Solanum melongena by Trichoderma spp. Biologia Plantarum 52, 582– 586
9. Deng, S., Lorito, M., Penttilä, M., & Harman, G. E. (2007). Overexpression of an endochitinase gene (ThEn-42) in Trichoderma atroviride for increased production of antifungal enzymes and enhanced antagonist action against pathogenic fungi. *Applied biochemistry and biotechnology*, *142*(1), 81-94.
10. Doley, K., & Jite, P. K. (2012). In-vitro efficacy of Trichoderma viride against Sclerotium rolfsii and Macrophomina phaseolina. *Notulae Scientia Biologicae*, *4*(4), 39-44.
11. Doley, K., Dudhane, M., & Borde, M. (2017). Biocontrol of Sclerotium rolfsii in groundnut by using microbial inoculants. *Notulae Scientia Biologicae*, *9*(1), 124-130.
12. Guzmán-Valle, P., Bravo-Luna, L., Montes-Belmont, R., Guigón-López, C., & Sepúlveda-Jiménez, G. (2014). Induction of resistance to *Sclerotium rolfsii* in different varieties of onion by inoculation with *Trichoderma asperellum*. *European journal of plant pathology*, *138*(2), 223-229.
13. Linderman, R. G., & Gilbert, R. G. (1973). Behavior of sclerotia of *Sclerotium rolfsii* produced in soil or in culture regarding germination stimulation by volatiles, fungistasis, and sodium hypochlorite treatment. *Phytopathology*.
14. Loc, N. H., Huy, N. D., Quang, H. T., Lan, T. T., & Thu Ha, T. T. (2020). Characterization and antifungal activity of extracellular chitinase from a biocontrol fungus, *Trichoderma asperellum* PQ34. *Mycology*, *11*(1), 38-48.
15. Manjula, K., Kishore, G. K., Girish, A. G., & Singh, S. D. (2004). Combined application of *Pseudomonas fluorescens* and *Trichoderma viride* has an improved biocontrol activity against stem rot in groundnut. *Plant Pathology Journal*, *20*(1), 75-80.
16. Mark, G. L., Morrissey, J. P., Higgins, P., & O'gara, F. (2006). Molecular-based strategies to exploit Pseudomonas biocontrol strains for environmental biotechnology applications. *FEMS microbiology ecology*, *56*(2), 167-177.
17. Naher, L., Yusuf, U. K., Ismail, A., & Hossain, K. (2014). Trichoderma spp.: a biocontrol agent for sustainable management of plant diseases. *Pak. J. Bot*, *46*(4), 1489-1493.

18. Nor, H. A., & Norazwina, Z. (2018). Isolation and identification of soil fungi isolates from forest soil for flooded soil recovery, IOP Conf. *Series*, *342*(012028), 1-10.
19. Parmar, H. J., Hassan, M. M., Bodar, N. P., Umrania, V. V., Patel, S. V., & Lakhani, H. N. (2015). In vitro antagonism between phytopathogenic fungi *Sclerotium rolfsii* and *Trichoderma* strains. *International Journal of Applied Sciences and Biotechnology*, *3*(1), 16-19.
20. Punja ZK, Rahe JE, 1992. Sclerotium. pp. 166- 170. In: Methods for research on soilborne phytopathogenic fungi. (Eds.): L.L. Singleton, J.D. Mihail and C.M. Rush. St. Paul: APS Press.
21. Radwan M, Fadel ALB, Mahareeq I, Mohammad IAL. Biological control of Sclerotium rolfsii by using indigenous Trichoderma spp. isolates from Palestine. Hebron Univ. Res., J.2006; 2(2): 27-47.
22. Rakh R. R., Raut L. S. and S. M. Dalvi (2020). *Bacillus spp.* for *In-Vitro* Microbiological Control of *Sclerotium rolfsii Sacc*., A Stem Rot Pathogen of Groundnut. Research Journal of Agricultural Sciences. 11 (3): 499-506.
23. Rakh R. R., S. M. Dalvi, L. S. Raut and A. V. Manwar (2022) Microbiological Management of Stem Rot Disease of Groundnut Caused by *Sclerotium rolfsii* Sacc., by Exploiting *Pseudomonas aeruginosa* AL98. *Res. Jr. of Agril. Sci.* (2022) 13:415–421
24. Rakh, R. R. (2010). Investigation on biological control of major groundnut Arachis hypogaea Linn diseases.
25. Siddiqui Z. A., and Shakeel U. (2006). Use of fluorescent pseudomonads isolates for the control of wilt disease complex of pigeonpea in greenhouse assay and under pot condition. *Pl. Pathol. J.* 5(1),99-105.
26. Singh, R., Maurya, S., & Upadhyay, R. S. (2016). The improvement of competitive saprophytic capabilities of Trichoderma species through the use of chemical mutagens. *Brazilian journal of microbiology*, *47*, 10-17.
27. Smith, A. F. (2002). Peanuts: The illustrious history of the goober pea (Vol. 20). University of Illinois Press.
28. Subrahmanyam. P., Mehan. V K . Nevlll, D J , and McDonald, D. 1980 Reseerch on fungal dlsoasns of groundnul a1 ICRISAT Pages 193 198 1n Pr~cood~rlys of the Inlernatlonal Workshop on (iroundnkrls. 13.11 Oct 1980. ICRISAT Center, lndla Patancheru, A P 502 324. lnd~a lnternal~onal Crops Research Inslltule for the Som~. AridTroplcs
29. Subramanian, C. V. (1971). Hyphomycetes. An account of Indian species, except *Cercosporae*. *Hyphomycetes. An account of Indian species, except Cercosporae.* pp 1 – 930.
30. Wonglom, P., Daengsuwan, W., Ito, S. I., & Sunpapao, A. (2019). Biological control of Sclerotium fruit rot of snake fruit and stem rot of lettuce by Trichoderma sp. T76-12/2 and the mechanisms involved. *Physiological and Molecular Plant Pathology*, *107*, 1-7.

Web links used:

1.(https://pjtsau.edu.in/files/AgriMkt/2018/GroundnutOLNov2018.pdf).

2.(https://angrau.ac.in/downloads/AMIC/GROUNDNUT%20OUTLOOK%20REPORT%20-%20January%20to%20May%202021.pdf).

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